PATENT SPECIFICATION

Convention Date (United States of America): July 3, 1943. **577,059**

Application Date (in United Kingdom): July 3, 1944. No. 12667/44.

Complete Specification Accepted: May 2, 1946.

COMPLETE SPECIFICATION

Method and Apparatus for Manufacturing Optical Prisms

We, KODAK LIMITED, a Company registered under the laws of Great Britain, of Kodak House, Kingsway, London, W.C.2, (Assignees of JOHN HENRY McLEOD and JOHN ROGERS TURNER, citizens of Canada and of the United States of America, respectively, and both of 1447 St. Paul Street, Rochester, New York, United States of America), do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The present invention relates to the manufacture of optical prisms.

The usual method of manufacturing optical prisms is to grind the prism surfaces by hand and then to block them in plaster of Paris to polish the surfaces. More recently prisms have been mounted in V-blocks for grinding and sometimes polishing, in an effort to speed up production. In this procedure, considering a prism having three surfaces, the prism is seated in a V-groove having plane walls in the blocking tool, two surfaces of the prism engaging two surfaces of the groove and being supported thereby so that the third face is exposed above the top surface of the blocking tool to the polishing action of a polishing tool.

This procedure has not proved entirely satisfactory for a number of reasons. First, it has proved costly, and sometimes impractical, to make the V-block with sufficient accuracy. Secondly, the prisms do not become properly seated in the block due to inaccuracy in the surfaces of the groove, inaccuracy in the ground surfaces of the prism, or inaccuracy in mounting. Finally, fundamental factors have been overlooked in the design of the block. It is primarily with the last two mentioned faults that the present invention is concerned. In addition, since all of the surfaces, or at least two surfaces in a three-sided prism, must be accurately hand ground to permit its cooperation with the V-groove in order accurately to control the plane of polishing of the third surface, this procedure in reality overcomes the hand grinding operation on only one side, and, therefore, increases production only to a limited extent.

An object of the present invention is to provide an improved blocking tool for grinding and polishing prisms, whereby all hand polishing and grinding operations, and the necessity for repeatedly measuring the angles of the prism during the grinding and polishing thereof are eliminated, thus contributing appreciably to increased production of prisms having prism angles within required rigid tolerances.

According to the present invention a blocking tool for prisms comprises a block having a top surface provided with a recess of suitable configuration to receive a prism a surface of which is to be ground and polished, and means in said recess adapted to engage two opposed surfaces of the prism when the same is seated in said recess to kinematically locate and support the prism with the surface thereof to be worked extending above the top surface of the block. The term "kinematic locating and supporting means" used herein refers to means which provides for adjustment of the prism relatively to the recess to enable cooperating surfaces of the prism and recess to define a required orientation of the prism with respect to the grinding plane.

Preferably, the kinematic locating and supporting means for the prism includes a first positioning means for engaging a given surface of the prism so as to locate and support said surface in a given plane relative to the top surface of the block, and a second positioning means for engaging an opposed surface of the prism in such a manner that a force resulting from a downward pressure on the prism will force the given surface of the prism into accurate contact with said first positioning means and will allow for a relative pivotal movement between said opposed surface and its positioning means to ensure the given surface of the prism properly engaging the positioning means therefor.

In carrying this preferred form of the invention into effect according to one form, the first positioning means com-

prises a plurality of spaced elongated and accurately formed bar supports provided on one wall of a V-groove or recess, the other wall of which is provided with the second positioning means comprising a single elongated bar support providing a line support for engaging a surface of the prism opposite that engaged by the plurality of spaced supports.

As will be hereinafter described in detail the present invention is applicable to prisms of different forms. In the particular case of more complicated forms of prism a third prism surface may be supported by a third positioning means of small area.

The present invention includes a method of grinding and polishing a prism in order to control a critical angle thereof, such method comprising grinding and polishing one of the surfaces bounding the angle, then using said finished surface in a blocking tool according to the invention to locate the other surface bounding the angle relatively to the grinding plane for the grinding and polishing operation.

In the accompanying drawings:—

Fig. 1 is a perspective view of a 45°—90° prism with dotted line extensions to illustrate pyramid error in a prism,

Fig. 2 is an end view of the prism shown in Fig. 1,

Fig. 3 is a vertical section of part of a blocking tool constructed in accordance with a preferred embodiment of the present invention, and adapted kinematically to locate and support a right angle prism for the finishing of one transmission surface thereof,

Figs. 4, 5 and 6 are vertical sections of parts of a set of three blocking tools for grinding and polishing the three surfaces of a Porro prism to control the 90° angle thereof and the pyramid error,

Fig. 7 is a vertical section of part of a blocking tool for use in the finishing of Dove prisms,

Figs. 8, 9, and 10 are three views of a roof prism, the manufacture of which can be speeded up and controlled by the method and apparatus of the present invention,

Fig. 11 is a plan view of part of a blocking tool adapted kinematically to locate and support the roof prism shown in Fig. 10 for the finishing of the first transmission face thereof in order to obtain an accurate 90° angle between the side walls of the prism and the planes of the transmission surfaces,

Fig. 12 is a vertical section taken substantially on the line XII—XII of Fig. 11, a roof prism being indicated in dotted lines,

Fig. 13 is an elevational view of part of a sew-tooth bar adapted to be set in a V-groove in the blocking tool of Figs. 11 and 12 to define recesses for a number of roof prisms,

Fig. 14 is a plan view of a blocking tool adapted kinematically to locate and support the roof prism for the finishing of the second transmission surface in order to obtain an accurate 90° angle between the two transmission surfaces, and

Fig. 15 is a vertical section taken substantially on the line XV—XV of Fig. 14 a roof prism being indicated in dotted lines.

An important consideration in the manufacture of some optical prisms is pyramid error. If a three-sided prism has its sides extended, it will taper off to a point and form a pyramid, if it has pyramid error. This is shown in an exaggerated manner in Fig. 1. The term pyramid angle used herein is to be understood as meaning the angle between the plane of one side of a triangular prism and the line of intersection of the other two sides. The pyramid angle of the triangular prism shown in Fig. 1 is the angle θ between the dihedral edge AD extended to the point B^1, and the plane BEFC extended to the point B^1. The pyramid angle might, however, be measured with reference to any one of the three dihedral edges and the plane of the opposite surface. It follows that a perfect prism would have zero pyramid angle because the dihedral edges would be parallel to one another.

As is well known in the art, prisms are ground and polished by mounting, or blocking, the same individually, or in groups, on a block with the surfaces to be worked exposed and located in a single plane above the top surface of the block. The block is then rotated or oscillated in a plane parallel to the exposed surfaces while a grinding and polishing tool capable of rotation or oscillation in a plane is brought into contact with the prism with a downward pressure normal to the surface of the prism being ground.

A blocking tool according to the present invention for a right-angle prism having three sides is illustrated in Figs. 3—6. Referring first to Fig. 3, a block 10 has a top surface 11 which is located parallel to the grinding and polishing plane when the block is mounted on a driving spindle, not shown, opposite a grinding and polishing tool, not shown, mounted to move in a plane for the grinding and polishing operations and to move bodily vertically relative to said plane to apply the necessary working pressure to the work. The top surface of the block 10 is provided

with one or more V-grooves 12 into which the prism 13 is inserted, as shown. Instead of the walls of the V-groove being smooth as is common practice, according to the present invention the walls of the grooves are undercut to provide a plurality of locating and supporting surfaces 14 on one wall and a single locating and supporting surface 15 on the other wall.

The plurality of locating and supporting surfaces 14 are for the purpose of engaging one surface of the prism and locating said surface in a given plane in order to locate a complementary surface of the prism with respect to the top surface of the block or the plane of grinding. In the present example of the invention, the supporting surfaces 14 comprises a pair of spaced supporting bars extending parallel to the vertex of the groove. Alternatively, a plurality of supporting surfaces located in spaced triangular relation could be provided instead.

The single locating surface 15 extends longitudinally of the V-groove parallel to the vertex thereof, and is adapted to engage one surface of the prism to prevent the prism from bearing to one side or the other. When the prism 13 is inserted into the groove in the manner shown in Fig. 3 and a downward pressure is applied to the exposed surface thereof, the single locating surface 15 will engage the hypotenuse surface and will, by virtue of its line contact therewith, permit adjustment of the prism to cause the confined transmission surface of the prism to be accurately located against the locating and supporting surfaces 14. Provided the locating surfaces 14 have been machined so that the plane they define is accurately 90 degrees with respect to the top surface of the block, and provided the transmission surface engaging them has been previously finished, then the angle 16 generated by grinding and polishing the exposed transmission surface will be 90°.

The single supporting surface 15 is preferably rounded as shown so that there will be no sharp corners to scratch the adjacent surface of the prism as the same slides over and tilts about said surface during the location of the prism in the block. The corners of the supporting surfaces 14 should also preferably be rounded off, even though the adjacent engaging surface of the prism does not tend to tilt about such surfaces 14. Surfaces 14 and 15 together provide a kinematic locating and supporting means for the prism relatively to the top surface of the block because they permit, and cause, an orientation of the prism to locate one surface thereof in the desired position relatively to the top surface of the block, the desired position of orientation being maintained so long as a normal downward force acting between the plane defined by the surface 14 and line of support afforded by the surface 15 is applied to the exposed surface of the prism during the grinding and polishing thereof.

The distance that the supporting surfaces extend from the walls of the groove is not critical, but it has been found that the walls of the groove need be undercut only a few thousandths of an inch (less than 0.010 and preferably 0.003 of an inch) when a prism with polished surfaces is to be mounted in the blocking tool. However, if prisms with rough surfaces are to be blocked, then it is important that a greater under-cut be provided to prevent the prism from resting against an accidental projection which would improperly locate the prism and give poor support. Instead of undercutting the walls of the V-groove to provide the supporting surfaces 14 and 15, the latter may be formed by bars secured to the walls of the grooves.

The undercut portions of the walls of the groove may be filled with wax to help support the portions of the prism surfaces not supported by the surfaces 14 and 15 and to help hold the prism in position in the groove. It is essential that the undercut be very shallow since waxes are very weak materials and would fail to give sufficient support under flexure if a very thick layer were bearing the load. Furthermore, shallow undercuts are important because they eliminate distortion in the prism, which distortion is so small that it is measured in wave lengths of light. While the wax may be forced into the undercuts in any one of a number of ways, it has been found that this can be done easily and efficiently by laying a strip of excessively waxed paper 17 of uniform thickness in the groove before the prism is inserted therein, as shown in Fig. 3. Then after the prism is properly seated on the supporting surfaces the block can be heated sufficiently to melt the wax whereupon that between the locating surfaces 14 and 15 and the prism surfaces will be forced out into the undercut to fill the same. The paper, as it is of very uniform thickness, will not affect the proper location of the prism by the kinematic locating and supporting means of the present invention.

The bottom of the V groove is cut out as shown at 18, Fig. 3, so that the corner of the prism extending into the groove is not subjected to pressure which would tend to chip the same. By virtue of the present invention, pressure is applied to parts of the prism surfaces well removed

from the prism corners so that chipping of the latter is eliminated. This is a distinct improvement compared with the blocking tool at present customary, as in known practice prisms are inserted into V grooves having smooth walls which provide an over-rigid support for the prism, and involve concentration of the pressure on the surfaces of the prism adjacent the corner in the groove with the result that chipping of the prism corners due to this pressure is very prevalent.

The plane defining or locating surfaces 14 may be provided on either wall of the V groove, depending upon the angle of the prism which is critical, as will be hereinafter described in connection with the application of the present invention to various prisms of common type.

One such common prism is the Porro prism, which is of the constant deviation type; it is important that the deviation be very nearly 180°. The angle that controls the deviation is the 90-degree angle, and for this reason the emphasis in manufacture of this prism should be on the generation of the 90-degree angle, rather than on the somewhat unimportant 45-degree angles. Pyramid error is also of some consequence in this prism. As set forth above, the pyramid angle of the prism is the angle between the plane of one side of a triangular prism and the line of intersection of the other two sides. Reference may therefore be made to pyramid angle or pyramid error with respect to the 90-degree edge or the 45-degree edge of a right-triangular prism, and the pyramid angle will have different values depending upon the reference edge. There can be no pyramid error in a triangular prism until the third side is generated, because the generation of the first two sides merely forms one reference edge which is the vertex of the dihedral angle formed by the two sides. It will be understood from an inspection of Figs. 1 and 2 that the pyramid angle with respect to the 90-degree edge is $\sqrt{2}$ times the error with respect to the 45-degree edge of a 45—90 triangular prism. Accordingly, the pyramid error in a 45—90 degree prism will be kept to a minimum if one of the short surfaces is ground last.

A set of prism blocking tools for the manufacture of Porro prisms and the sequence of operations that are in accord with the invention and the above introduction will now be described. Although the prisms may be operated on individually it is prefrred to operate on Porro prism sticks which have been made in the usual way from individual prisms connected together end to end by wax after their ends have been ground plano-parallel.

The first prism blocking tool is a 90-degree block as shown in Fig. 4, in which the top surface of the block is provided with a 90-degree V groove. The groove is undercut to provide two locating bars 14 on one wall and one locating bar 15 on the other wall to give kinematic support to the prism stick, as fully set forth above. No special accuracy is required in this block, the prisms being waxed into place and the hypotenuse surface being ground and polished plano first for the reason hereinafter explained.

The second blocking tool is a 45-degree block, as shown in Fig. 5, for grinding and polishing one of the reflecting surfaces of the prism. Two locating bars 14 are formed on the sloping wall of the groove and one locating bar 15 is formed on the vertical wall. This block controls one 45-degree angle of the prism and, therefore, the two bars 14 should be machined with fair accuracy so that the plane defined thereby will be truly 45° with respect to the top surface of the block which will be parallel to the plane of grinding when the block is mounted on the grinding and polishing machine. As shown in Fig. 5, the previously finished hypotenuse surface of the prism is located in this block by the two supporting bars 14 so that this surface in combination with said bars 14 controls the final plane of the first reflecting surface and, therefore, the dihedral angle formed by the said reflecting surface and the hypotenuse. The prism should be ground until the thickness of the exposed portion above the top surface of the block, and indicated by the dimensions " t " in Figure 5, is the same on both sides of the prism at any point on the block. This will ensure the dihedral angle being 45° and eliminate the necessity for repeatedly measuring this angle during the manufacture of the prism in order to determine when it is correct.

The third blocking tool is a 45-degree block, as shown in Fig. 6 and has two locating bars 14 on the 90°, or vertical, wall of the groove. The prism after having the hypotenuse surface and one reflecting surface finished in the first and second blocking tools is mounted in the third blocking tool with the finished reflecting surface engaging the two locating bars 14, as shown, for grinding and polishing the second reflecting surface. This is the really important blocking tool in the manufacture of Porro prisms because it controls both the 90-degree angle of the prism, which is the critical one, and also controls the pyramid angle.

Accordingly, locating bars 14 on the vertical wall of the groove must be machined so that the plane defined thereby makes an accurate 90-degree angle with the top surface of the blocking tool. In addition, each groove should be of the same depth from end to end, otherwise pyramid angle errors will occur in the prism. Stating it more accurately, if the prism does not actually engage the vertex of the V groove, as shown, the locating bars 14 and 15 should be machined so that they will accurately kinematically locate and support the prism so that the reference edge of the prism formed by the intersection of the finished hypotenuse surface and the first reflecting surface will be truly parallel to the top of the block. The prisms should be ground until the dimension "t" between the top of the block and the exposed surface of the prism, see Fig. 6, is the same all around the block.

The reason why the two 45-degree blocking tools are not used before the 90-degree blocking tool is that it is only when the third surface is generated that the pyramid angle has any meaning, as above set forth. It was pointed out earlier that the pyramid error is $\sqrt{2}$ times greater with reference to the 90-degree edge than with respect to the 45-degree edge. Therefore, the prism should be blocked with respect to the 45-degree edge when the third and last surface is generated. The reason why similar blocking tools are not used for the second and third prism surfaces, is that two errors in the 45-degree angle would add up to make an error in the 90-degree angle which is the critical one.

So far as we are aware, the method according to the present invention of manufacturing Porro prisms is radically different from that commonly practiced. In the first place, it is the usual practice in the anufacture of Porro prisms to grind and polish the two short sides first and hypotenuse last, primarily because the hypotenuse offers the greatset supporting surface; and with hand polishing operations and inadequate blocking means heretofore used, it was necessary to grind and polish the surfaces in the order permitting the hypotenuse surface to be used to control the pyramid error and two of the three angles of the prism. In this manner the 45° angles are the one controlled rather than the 90° angle as desired. By virtue of the means according to the present invention for kinematically locating and supporting prisms in a blocking tool, the prism can be accurately positioned to generate any surface in a given angular relation to a previously finished surface, the latter surface controlling the angular relationship of the two during the blocking operation. The present invention greatly speeds up the manufacture of prisms because the repeated testing of the angle being generated is eliminated.

The manufacture of a right-angle prism which is to be used to give one total reflection from the hypotenuse will now be considered. If such a prism is to be rotatable to swing a light beam at various angles and if the direction of the beam is to be measured from the rotation of the prism, it is important that the two 45-degree angles be equal to each other. Errors in the 90-degree angle are of little or no importance. Pyramid error is usually important in this use of a right-angle prism.

Therefore, in order to manufacture a right-angle prism for this use the prism should be blocked in a 90-degree blocking groove for the generation of the hypotenuse surface as set forth above in connection with the manufacture of the Porro prism. The second and third 45-degree blocks, however, should both have the two locating bars 14 on the 45-degree wall of the V groove so that the previously finished hypotenuse surface will control the generation of the two 45-degree angles of the prism, and the pyramid error will be controlled with reference to a 45-degree edge as is desired. In fact, it is desirable to use the same 45-degree blocking tool for the generation of the two transmission surfaces of this type of prism, and the prism should even be supported in the same identical groove for second and third side blocking. To accomplish this it is merely necessary to turn the prism, or stick or prisms, end for end in the blocking groocve. Thus, if the 45-degree angle is in error in a groove, it will mean that both 45-degree angles of a prism made in that groove will be in error by the same amount, and, therefore, the prism will perform perfectly. Of course, for both the second and third surfaces the plane of grinding should be parallel to the top of the block.

In the Dove prism the light strikes one sides of the prism at 45° and is refracted toward the hypotenuse. The hypotenuse totally reflects the light to the third side where it is refracted and leaves at 45° to that side. The deviation is usually zero but may be varied by tipping the prism, and the image is inverted. One application of such a prism is in a panoramic sight to keep the image right side up. The prism can be tilted to adjust the deviation to zero in one direction, but the deviation in the other direction is a func-

tion of pyramid angle and cannot be corrected in mounting. In this case, therefore, the only angle of any importance is pyramid angle. Therefore, Dove prisms should be kinematically blocked in a 45-degree block for the generation of the last transmission surface, the hypotenuse and first transmission surfaces being previously finished in the order set forth above by being blocked in 90-degree and 45-degree blocks respectively. Careful attention should also be given to having the finished 45-degree reference edge supported parallel to the top of the block and to grinding the last transmission surfaces parallel to the top of the block. Fig. 7 shows the manner in which the Dove prism should be blocked for generation of the last transmission surface. Illustrations of the manner of blocking the prism for the generation of the hypotenuse and first transmission surface of the Dove prism in that order have not been shown, for the reason that they will be substantially the same as the first and second blocking means for the 45°—90° prism previously described.

The method and apparatus according to the invention is also adapted for grinding and polishing the surfaces of more complicated prisms in order to control a given angle which may be critical. By way of example, the application of the invention to the finishing of the transmission surfaces of a roof prism will now be considered with reference to Figs. 8, 9, and 10, Fig. 8 being a side view of the prism, Fig. 9 being a plan view of the prism looking down on the transmission surface shown horizontally in Fig. 8, and Fig. 10 being a perspective view of the prism. With this prism, the light enters one transmission surface T_1, strikes the first roof surface R_1 and is reflected thereby to the second roof surface R_2 which in turn reflects it towards the second transmission surface T_2 from which it emerges, all as indicated by the ray diagrams shown in Figs. 8 and 9. A specific problem is to generate the transmission surfaces T_1 and T_2 perpendicular to the plano-parallel ground sides S_1 and S_2 of the prism as well as to maintain a 90-degree angle between the two transmission surfaces.

According to the present invention, a set of blocking tools for this type of prism may take the form shown in Figs. 11, 12, 14, and 15, according to which a blocking tool adapted to accommodate a plurality of roof prisms at one time comprises a block 20 the top surface 21 of which is provided with one or more V grooves 22 in each of which is mounted a saw-tooth bar 23 of the form shown in Fig. 13. The bar 23 has a plane bottom surface 24 and the top surface is provided with a plurality of similar notches 25 spaced longitudinally thereof in each of which a roof prism is seated. Each notch 25 includes two inclined walls 26 and 27 adapted to accommodate the roof surfaces of the prism. These inclined walls 26 and 27 join vertical walls 28, 29 which are substantially parallel to the plano-parallel sides S_1 and S_2 of the prism when the latter is seated in the notch. As shown in Figs. 11, 12, 13 and 14, the bar 23 is located in the V groove with the bottom surface 24 engaging the inclined wall of the groove. Consequently, the vertex 30 of each saw-tooth or notch 25 is inclined parallel to the inclined wall of the V groove. By this arrangement of parts, each notch in the bar 23 in combination with the vertical wall W of the V groove forms a recess into which a roof prism may be seated with one of its transmission surfaces exposed above the top surface of the block for grinding and polishing, see Figs. 12 and 15.

According to the present invention two blocking tools are each provided with kinematic locating and supporting means for the roof prism in the recesses so that the transmission surfaces can be ground in perpendicular relation to the plano-parallel side walls of the prism and at a true 90-degree angle with respect to each other. One tool is provided for grinding and polishing one transmission face, and the other tool for the other transmission face. The tool for blocking the prism for grinding the first transmission surface, is illustrated in Figs. 11 and 12, according to which one vertical side wall 28 of the notch 25 is provided with a pair of spaced supporting bars 41 the surfaces of which are machined to define a plane perpendicular to the top of the block. These bars are adapted to engage the plano-parallel side wall S_1 of the prism when it is seated in the recess and thereby to control the angular relation between the grinding plane and this surface. The vertical wall of the V groove 22 opposite each recess is provided with a single bar support 32 for engaging one of the rough moulded transmission surface of the prism, and the inclined wall 27 of the recess is provided with a supporting member 33 of limited area which constitutes a point support for one of the roof surfaces of the prism. Accordingly, when the prism is placed in the recess with one of the transmission surfaces exposed above the top of the block and a downward pressure is applied thereto, cooperation between the single point support and the single bar support will cause the prism to be located in the recess

with its plano-parallel ground side in proper engagement with the double bar support, whereby the same will be accurately located in a plane perpendicular to the grinding plane. Therefore, the double bar support, the single bar support and the single point support in combination constitute a kinematic pyramidal locating means for the prism. The prism is thus located in a desired position of orientation by engaging three sides thereof by means which constitute a plane support for the one side which is to control the orientation of the prism, a line support for another side of the prism and a point support for a third side. The line and point supports allow for, and cause, an adjustment of the prism necessary to position the controlling side properly against the plane-defining support, and there after cooperate with the plane-defining support to securely hold the prism in the desired position of orientation. In grinding and polishing the second transmission surface of the prism, the prime consideration is to generate a true 90-degree angle between the two transmission surfaces. To effect this, a second blocking tool shown in Figs. 14 and 15 is used. This blocking tool differs from the blocking tool described with reference to Figs. 11—12 only in the position of the supporting surfaces for the respective sides of the prism. In this second tool the plane-defining supports of the kinematic locating means engage the previously finished transmission face of the prism because this is the surface that is to control the 90-degree angle. Accordingly, a pair of horizontal spaced bars 31^1 are provided on the vertical wall W of the V groove to engage and locate the transmission surface, previously finished in the first block, the single supporting bar 32^1 is located on the vertical wall 28^1 of the recess, and a supporting member 33^1 of limited area is provided on the inclined wall of the recess which is opposite to the vertical side having the single bar support. The three supporting means constitute a kinematic pyramidal locating means as before, but the previously finished transmission surface of the prism controls the orientation of the prism instead of the plano-parallel side. It is important that the resultant force on the surface being finished falls between the points of support for the three surfaces of the prism rather than outside of them, otherwise, the locating means may be kinematically unstable.

From the above description it will be appreciated that the present invention makes it possible to control the orientation of the prism so that the grinding of any surface can be accurately controlled with rsepect to another surface, and ensures that the prism is held in a desired position of orientation. The improved blocking tool also speeds up the manufacture of optical prisms in that it eliminates the necessity of repeatedly checking the angles of the prism throughout the finishing operation in order to be sure when they are correct. In addition, by use of such a blocking tool, pressure on the prism surfaces can be removed from the weak parts, viz. the corners, and the waste due to chipped corners, which is prevalent with present practice where the prisms are over-rigidly supported when blocked, is eliminated. The kinematic locating and supporting means, because of its ability to control accurately the orientation of a prism relatively to the grinding and polishing plane and with reference to a given surface of the prism, is a commercially practicable means by which the critical angle of a prism, as determined by its function, can be accurately controlled. The present invention is not limited to use with the specific types of prisms hereinbefore described but can be adapted to any type of prism which might be encountered.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A blocking tool for prisms comprising a block having a top surface provided with a recess of suitable configuration to receive a prism a surface of which is to be ground and polished, and means in said recess adapted to engage two opposed surfaces of the prism when the same is seated in said recess to kinematically locate and support the prism with the surface thereof to be worked extending above the top surface of the block.

2. A blocking tool according to claim 1, in which the kinematic locating and supporting means for the prism includes a first positioning means for engaging a given surface of the prism so as to locate and support said surface in a given plane relative to the top surface of the block, and a second positioning means for engaging an opposed surface of the prism in such a manner that a force resulting from a downward pressure on the prism will force the given surface of the prism into accurate contact with said first positioning means and will allow for a relative pivotal movement between said opposed surface and its positioning means to ensure the given surface of the prism properly engaging the positioning means therefor.

3. A blocking tool according to claim 1, in which the kinematic locating and supporting means for the prism includes a plurality of spaced supports adapted to engage a given surface of the prism to locate and support the same in a given plane relative to the top surface of the block, and a plurality of supports for engaging an opposed surface of the prism in a line parallel to the plane defined by said first mentioned supports, each group of supports being so located relatively to one another that a resultant downward force on the prism will fall between them.

4. A blocking tool according to claim 1, in which the kinematic locating and supporting means for the prism includes a pair of elongated bar supports in spaced relation adapted to engage a given surface of the prism to locate and support the same in a given plane relative to the top surface of the block, and a single elongated bar supports substantially parallel to the plane defined by said two first mentioned bar supports for engaging an opposed surface of the prism in a line, the supports for the respective prism surfaces being so located relatively to one another that a resultant downward force on the prism will fall between them.

5. A blocking tool for prisms comprising a block having a top surface provided with a V-groove to receive a prism a surface of which is to be ground and polished, spaced locating and supporting surfaces extending from one surface of said V-groove and adapted to engage a given surface of a prism seated in said groove and locate said susrface in a given plane relative to the top of said block, a locating and supporting surface extending from the other surface of said groove and adapted to engage an adjacent surface of the prism in a line contact substantially parallel to the vertex of the groove, said supporting surfaces in combination constituting a kinematic locating and supporting means for the prism by virtue of which the given surface of the prism is adapted to be accurately positioned against said supporting surfaces therefor by a resultant downward pressure on the prism.

6. A blocking tool for prisms according to claim 5 wherein the spaced locating surfaces comprise a pair of elongated bar supports extending from one surface of the V-groove and extending lengthwise of, and being substantially parallel to the vertex of the groove and adapted to engage a given surface of the prism to locate and support the same in a given plane relative to the top surface of the block, and the locating surface extending from the other surface of the groove comprises a single elongated bar support extending in substantially parallel relation to the other bar supports and adapted to have line contact with an opposed surface of the prism.

7. A blocking tool for the use in grinding and polishing a transmission surface of a roof prism and comprising a block having its top surface provided with a recess of suitable configuration to receive said prism oriented so that the transmission surface thereof to be worked is substantially parallel to and extends above said top surface of the block, a plurality of spaced supports extending from one wall of the recess adapted to engage the other transmission face of the prism and locate it accurately in a plane at right angles to the top surface of the block, an elongated support extending from another wall of said recess and adapted to engage one of the plano-side walls of the prism in a line substantially parallel to the plane defined by said first mentioned spaced supports, and a supporting post extending from a third wall of said recess at an angle to the vertical and inclined towards the plane and line of support provided by said aforementioned supporting means, the end of said post adapted to engage the roof surface of said prism opposed to the plane side wall mentioned, said supporting means for the three surfaces of the prism in combination providing a kinematic locating and supporting means for the prism by virtue of which said second transmission surface is accurately moved into, and held in, engagement with the spaced supports therefor by a resultant downward pressure on the transmission surface of the prism to be ground and polished.

8. A set of blocking tools to be used in grinding and polishing the three surfaces of a Porro prism so as to accurately control the 90° angle and overcome pyramid error and comprising in combination a first blocking tool provided with a 90° V-groove in its top surface with the walls of the groove each inclined at 45° to the top surface of the block to receive the prism for working the hypotenuse face thereof, a plurality of spaced supports extending from one wall of the groove and adapted to engage and locate one reflecting surface of the prism in a plane at 45° to the top surface of the block, an elongated bar support extending from the other wall of said groove and adapted to engage the other reflecting surface of the prism in a line substantially parallel to the vertex of the groove, said supporting means for the two reflecting surfaces constituting a kinematic locating and supporting means to accurately support the

prism for the working of the hypotenuse face of the prism a second blocking tool provided with a 45° V-groove in its top surface into which the prism is to be seated for working the first reflecting surface, one wall of said groove extending at 90° to the top surface of the block, a plurality of spaced supports extending from the inclined wall of said groove and adapted to engage and locate the previously polished hypotenuse face in a plane at 45° to the top surface of the block, an elongated bar support extending from the vertical wall of said groove and adapted to engage the second reflecting surface of the prism in a line substantially parallel to the vertex of the groove, said supporting means for the hypotenuse and second reflecting surface constituting a kinematic locating and supporting means to accurately support the prism for the working of the first reflection surface with regard to the previously finished hypotenuse surface; and a third blocking tool provided with a 45° V-groove in its top surface in which the prism is to be seated for finishing the second reflecting surface, one wall of said groove extending at 90° to the top surface of the block, a plurality of spaced supports extending from the vertical wall of said groove and adapted to engage and locate the previously finished reflecting surface in a plane at 90° to the top surface of the block, an elongated bar support extending from the 45° wall of the groove and adapted to engage the finished hypotenuse surface in a line substantially parallel to the vertex of the groove, said supporting means for the finished reflecting surface and the hypotenuse constituting a kinematic locating and supporting means to accurately support the prism for finishing the second reflecting surface with regard to the previously finished reflecting surface, whereby the 90° angle and pyramid error of the prism are accurately controlled.

9. A set of blocking tools to be used in grinding and polishing the three surfaces of a right angle prism to be used with one total reflection from the hypotenuse so as to accurately control the two 45° angles and overcome pyramid error, and comprising a first blocking tool provided with 90° V-groove in its top surface and the walls of which are each inclined at 45° to the top surface of the block to receive the prism for working the hypotenuse face thereof, a plurality of spaced supports extending from one wall of the groove and adapted to engage and locate one transmission surface of the prism in a plane at 45° to the top surface of the block, an elongated bar support extending from the other wall of said groove and adapted to engage the other transmission face of the prism in a line substantially parallel to the vertex of the groove, said supporting means for the two transmission surfaces constituting a kinematic locating and supporting means to accurately support the prism for the working of the hypotenuse face, and a second blocking tool provided with a 45° V-groove in its top surface into which the prism is to be seated for working the two transmission faces in turn, one wall of said groove extending at 90° to the top surface of the block, a plurality of spaced supports extending from the inclined wall of said groove and adapted to engage and locate the previously finished hypotenuse face in a plane at 45° to the top surface of the block, and an elongated bar support extending from the vertical wall of said groove and adapted to engage the transmission surface not being worked in a line substantially parallel to the vertex of the groove, said supporting means for the hypotenuse and one transmission surface constituting a kinematic locating and supporting means to accurately support the prism for the working of the two transmission surfaces with respect to the previously finished hypotenuse surface, whereby the two 45° angles and the pyramid error of the prism are accurately controlled.

10. The method of grinding and polishing the surfaces of a prism in order to accurately control the angle thereof which is critical with respect to its intended use and comprising the steps of kinematically locating and supporting the prism in a blocking recess of suitable configuration with one surface thereof constituting a side of the critical angle exposed for grinding and polishing said surface, then again kinematically locating and supporting said prism in a blocking recess of suitable configuration with the other surface thereof constituting the other side of the critical angle exposed for grinding and polishing so that said previously finished surface of said prism controls the location of said prism in said recess with respect to the grinding and polishing said last mentioned surface.

11. The method of grinding and polishing the surfaces of a Porro prism in order to accurately control the 90° angle and the pyramid angle thereof and comprising the steps of grinding and polishing the hypotenuse surface thereof, kinematically locating and supporting the prism in a 45° blocking groove so that one of the transmission surfaces is exposed for grinding and polishing and the previously finished hypotenuse controls the

position of said surface relative to the grinding and polishing plane, grinding and polishing said transmission surface, removing the prism from said blocking groove, kinematically locating and supporting the prism in a second 45° blocking groove so that the second transmission surface is exposed for grinding and polishing and the previously finished transmission surface controls the position of said second transmission surface relative to the grinding and polishing plane and locates said plane of grinding and polishing at 90° to itself, and grinding and polishing said second transmission surface.

12. The method of grinding and polishing the surfaces of a 45°—90° prism in order to control the 45° angles and the pyramid angle thereof and comprising the steps of grinding and polishing the hypotenuse surface thereof, kinematically locating and supporting the prism in a 45° blocking groove, one wall of which is vertical with respect to the grinding and polishing plane, so that one of the reflecting surfaces is exposed for grinding and polishing and the previously finished hypotenuse face controls the position of said surface relative to the grinding and polishing plane, grinding and polishing said reflecting surface, turning said prism end for end in said groove and again kinematically locating and supporting the prism so that the other reflecting surface is exposed for grinding and polishing and the previously finished hypotenuse surface controls the position of said surface relative to the grinding and polishing plane, and grinding and polishing said second reflecting surface.

13. The method of grinding and polishing the surfaces of a 45°—90° prism in order to control the 45° angles and the pyramid angle thereof and comprising the steps of grinding and polishing the hypotenuse surface thereof, kinematically locating and supporting the prism in a 45° blocking groove, one wall of which is vertical with respect to the grinding and polishing plane and the other wall of which is inclined at 45° to said plane, so that one of the reflecting surfaces is exposed for grinding and polishing and the previously finished hypotenuse face controls the position of said surface relative to the grinding and polishing plane, grinding and polishing said reflecting surface, removing the prism from said groove, and kinematically locating and supporting the same in a second groove similar to the first so that the other reflecting surface is exposed for grinding and polishing, and the previously finished hypotenuse surface controls the position of said surface relative to the grinding and polishing plane, and grinding and polishing said second reflecting surface.

14. The method of grinding and polishing the two transmission and reflecting surfaces of a Dove prism in order to overcome pyramid error and comprising the steps of grinding and polishing the reflecting surface thereof, kinematically locating and supporting the prism in a 45° blocking groove, one wall of which is perpendicular to the grinding plane and the other wall of which is inclined at 45° to said plane, so that one of the transmission surfaces is exposed for grinding and polishing and the previously finished reflecting surface is located in a plane at 45° to said plane, grinding and polishing said transmission surface, removing the prism from said groove, kinematically locating and supporting the prism in a similar groove so that the other transmission surface is exposed for grinding and polishing and the previously finished reflecting surface is again located in a plane at 45° to said grinding and polishing plane and the edge between the finished reflecting and transmission surfaces is located parallel to said plane, and grinding and polishing said second transmission surface.

15. A set of optical prism blocking tools constructed and adapted for use substantially as hereinbefore described with reference to Figs. 4—6 or Figs. 11—15 of the accompanying drawings.

Dated this 3rd day of July 1944.

RAYMOND E. CROWTHER.
Acting for the Applicants.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1946. Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies, price 1s. 0d. each (inland) 1s. 1d. (abroad) may be obtained.

[This Drawing is a reproduction of the Original on a reduced scale.]

FIG. 1.

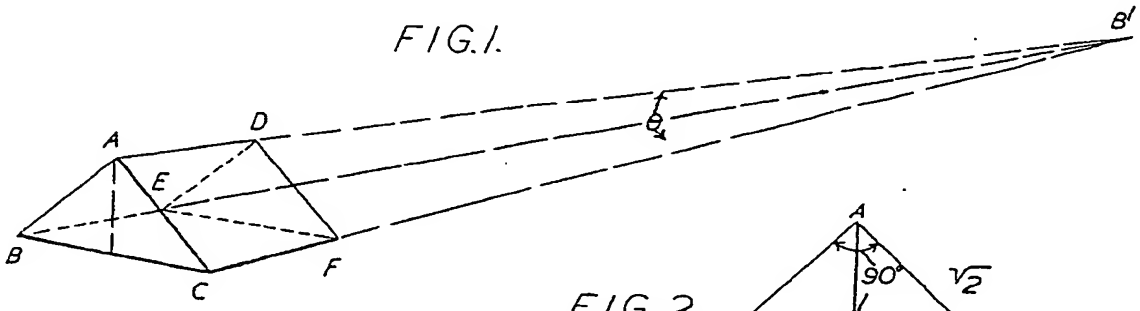


FIG. 2.

FIG. 3.

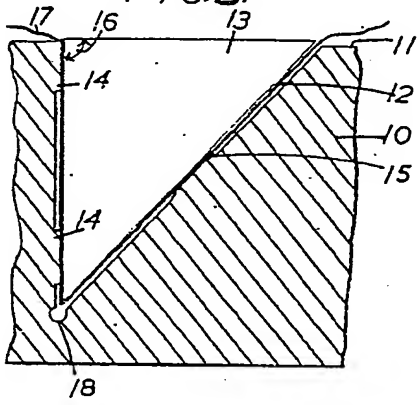


FIG. 4.

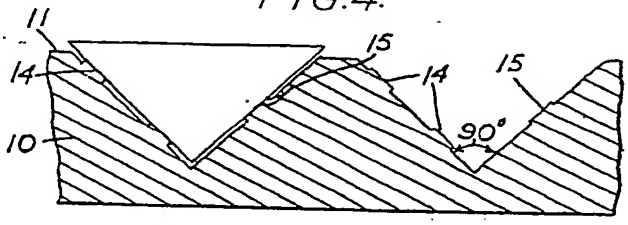
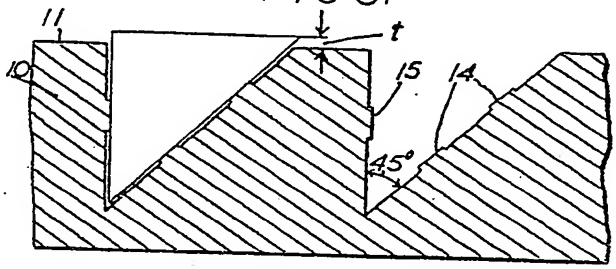


FIG. 5.



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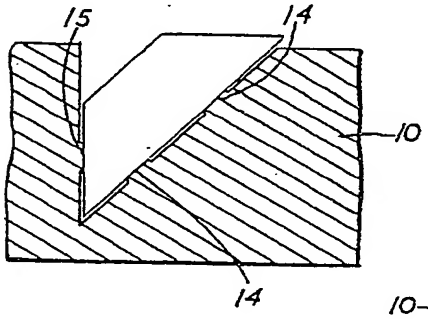

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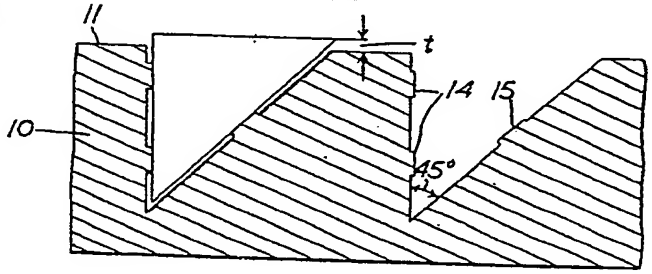


SHEET 1

B'

C

5

FIG.8.

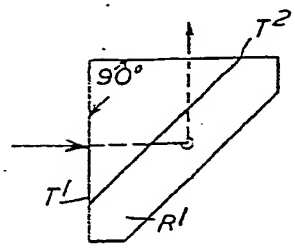
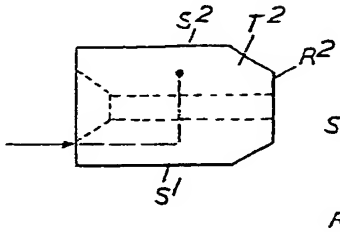


FIG.9.



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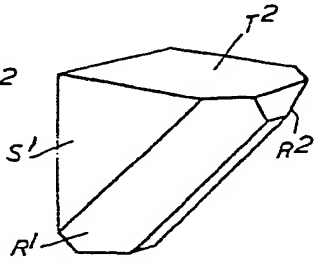

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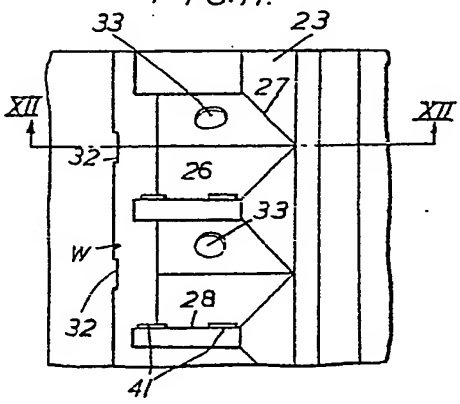

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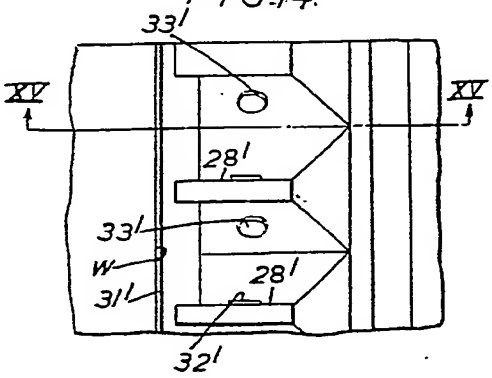

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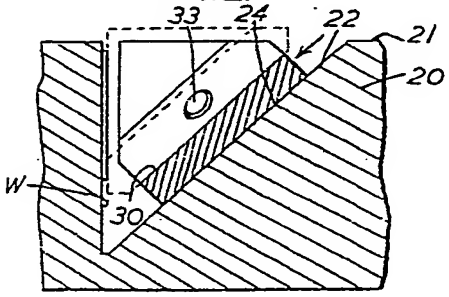

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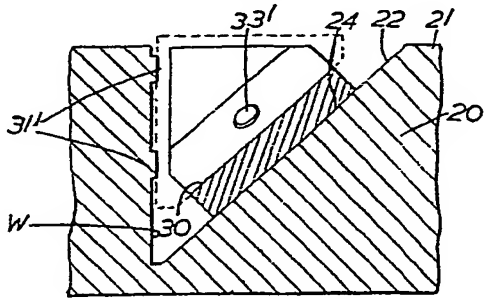

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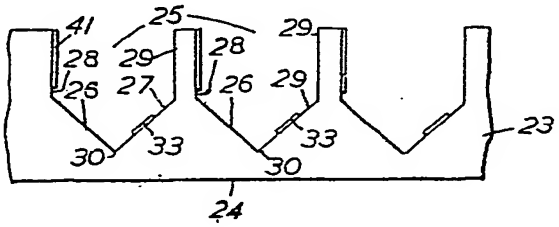

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577,059 COMPLETE SPECIFICATION

2 SHEETS

SHEET 1

SHEET 2

FIG.1.

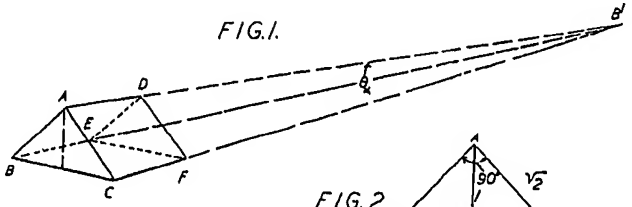
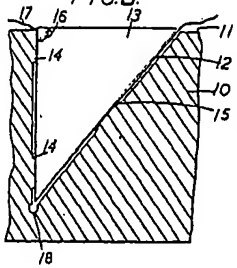


FIG.2.

FIG.3.



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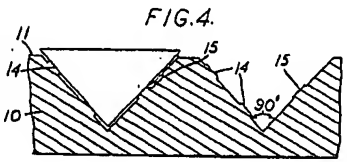
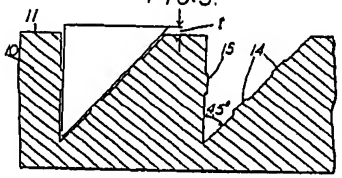


FIG.5.



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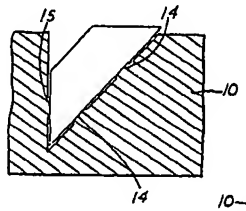
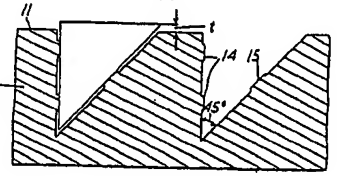


FIG.6.



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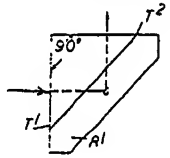

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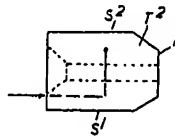


FIG.10.

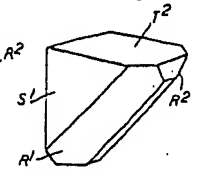


FIG.11.

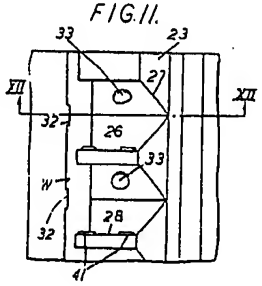


FIG.14.

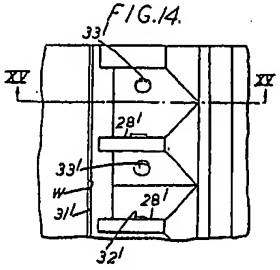
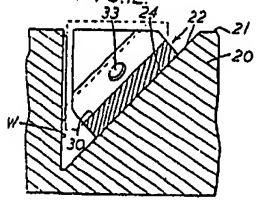


FIG.12.



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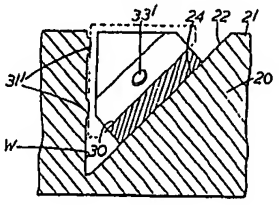

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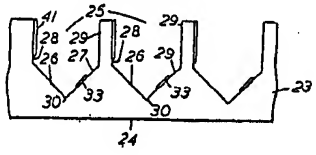

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